

Stacking Strength

in **TOPS** for Windows

TOPS for Windows implements the McKee formula for calculating the Stacking Strength of regular slotted containers (RSC's). NOTE: While TOPS implements this generally accepted design formula, it is still up to the Packaging Engineer to evaluate the degree to which this formula might apply. NOTE: In v3.51 TOPS added support for the Kellicut calculation (not yet documented).

Stacking Strength evaluations in TOPS normally begin by building the desired pallet pattern and selecting the *Tools/Stacking Strength* menu item. To evaluate strength without building a pallet, hit the QUICK STR button when no analysis has yet been started. (This quick method is actually more work, unless all you are concerned with is Lab Compression.) NOTE: Unless otherwise specified, all menu item references apply to the TOPS for Windows **CONFIG** program.

The McKee Formula

$$\text{McKee Formula} = (\text{FC}) \times (\text{ECT}) \times (\text{BP})^{.4924} \times (\text{Caliper})^{.5076}$$

$$\text{TOPS Lab Compression} = (\text{McKee Formula}) \times (\text{Shape Factor}) \times (\text{Length to Width Ratio Factor}) \times (\text{Horizontal Flute Factor}) \times (\text{Printing Factor})$$

$$\text{TOPS Box Performance} = (\text{Lab Compression}) \times (\text{Flap Gap Factor}) \times (\text{Humidity Factor}) \times (\text{Storage Time Factor}) \times (\text{Pallet Spacing Factor}) \times (\text{Interlock Factor}) \times (\text{Overhang Factor}) + \{\text{Product Support}\}$$

FC = Flute Constant (5.87)

ECT = Edge Crush Test

BP = Box Perimeter

Overhang Factor = $1 - (\text{minimum of } \{ (\text{square root of Overhang}) \times 32.25 \div 100, 1 \})$

Horizontal Flute Factor (HFF) = 1 unless non-vertical flute selected. If non-vertical flute selected, HFF is looked up for the specific board grade. however, there is no generally accepted industry standard for the amount a non-vertical flute's compression would degrade. TOPS currently ships with a HFF of .9 for a 10% reduction (obviously not enough). HFF adjustments done under *Definitions/Board Combinations*.

Shape Factor = Table lookup based on proportions of box (relative to box depth) and dimension vertical. Adjusted through *Definitions/Box Design Factors* (see page #3).

Printing Factor = Table lookup based on printing type and quantity. Adjusted through *Definitions/Box Design Factors*.

All other Factors are looked up in the table of environmental factors in the CONFIG program. (See below).

Environmental factors which the McKee formula doesn't yet account for include: rough handling, transportation conditions, worker's sitting on the box, die cuts, adhesive additives, etc.

User's may adjust their stacking strength variables through use of:

1. *Definitions/Board Combinations* - Adjusts board grades, including changing, deleting, or marking them unavailable. Use to adjust a board's ECT or cost per 1000 sq. ft.
2. *Definitions/Flutes* - Adjusts base flutes. (Such as the default thickness or flute constant.)
3. *Definitions/Environmental Factors* - Adjusts Humidity, Storage Time, Interlock, and Pallet Spacing lookup values (see page #3).
4. *Definitions/Paper* - Adjusts paper Ring Crush Values.
5. *Definitions/Dividers* - Adjusts Divider definitions (found in the main TOPSWIN program).



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TOPS for Windows Stacking Strength Results

Untitled Pallet: GMA (Notched) (48.0 x 40.0)
 Length: 19.0000 Flute Dir: Along Depth
 Width: 14.0000 Flap Gap: 0.0000 Brd Spacing: 2.6667 Cs/Layer: 7 (7)
 Height: 10.0000 Dim Vert: Depth Overhang: 1.0000 Layers/load: 5
 Weight: 25.00 Printing: Simple Humidity: 75 Interlock: All
 Prod Sup: 0.00 Div Style: (01) 6-WAY CEILING Stg Time: 3 Months

Same Flute - Same Board

At 2 Loads High, bottom case must support 224.29 lbs

Calculation Method: Ring Crush

Board Description	Construction	Flute	Lab Div	Lab Box	Total Lab	Box Perf.	Safety Factor	Safety Margin	Loads High	ECT lbs/in	Cost /1000ft2
275-MULLEN	69-33M-69	B	257.5	1030.2	1287.7	236.8	5.50	1%	2.0	62.4	0.000
40#ECT	42-36M-69	C	255.9	1023.5	1279.4	235.3	5.46	0%	2.0	55.0	0.000
44#ECT	35HR-40M-56HR	C	261.3	1045.1	1306.3	240.2	5.58	3%	2.0	57.0	0.000
44#ECT	45HR-40M-45HR	C	263.2	1052.8	1316.0	242.0	5.62	3%	2.1	57.4	0.000
44#ECT	56HR-26M-56HR	C	260.9	1043.8	1304.7	239.9	5.57	2%	2.0	56.6	0.000
44#ECT	56HR-36M-56HR	B	254.2	1016.8	1271.0	233.7	5.42	-0%	2.0	62.6	0.000
44#ECT	69-33M-69	B	260.5	1041.8	1302.3	239.5	5.56	2%	2.0	62.4	0.000

- A.** Amount of weight that a box on the bottom layer of bottom pallet must support.
- B.** Lab Compression of the divider (See **D** for more on Lab Comp). This column will only appear if you have specified a divider. New Dividers are defined using the Definitions|Dividers menu item. Each divider has a support factor that determines the amount of additional support that divider adds. (A support factor of 1 = no change.)
- C.** Lab Compression of the box without the divider (See **D** for more on Lab Comp). This column will only appear if you have specified a divider.
- D.** Total Lab Compression - See **Lab Compression** on page 1. If you have defined a divider this will be the sum of the divider compression and box lab compression. (i.e. **D=B+C**)
- E.** Box Performance - The resulting compression strength taking into account the environmental conditions you've specified. **See Box Performance** on page 1.
- F.** Total Lab divided by the weight that the bottom case must support (i.e. **F=D/A**).
- G.** The percentage that the box performance exceeds the weight the bottom case must support. (i.e. **G=(E-A)/A**). Boards with Safety Margins that are greater than zero are highlighted in blue.
- H.** How many unitloads does it take to reach the limit (box performance) of a bottom most case.
- I.** The ECT of the board. If the calculation method is Edge Crush, it will be the empirical value entered for each board in the CONFIG program. If the calculation method is Ring Crush, the program will calculate the ECT from the Ring Crush Factor's (RCF) of each board's papers. (Unfortunately, the program will still print the empirical number. Will be fixed in a future release).
- J.** The cost per 1000 square feet as entered into the board grade database by the user.

Note: Prior to TPW v3.23, Compression was calculated using BP and Caliper to the .5 instead of their current exponents.

Suggestion: To reduce chances of "no answers" when calculating, don't filter (by lab, loads high, or safety factor) until after you have seen the resulting Boards Grades, then filter out the extras!



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Ring Crush to Edge Crush calculation

When entering a new Board combination and when using the "Ring Crush" calculation method, single and double wall ECT's are calculated from liner/medium ring crush factors as follows...

For Single Wall start with:

$$A = (\text{Liner1 RCF}) + (\text{Liner2 RCF}) + (\text{Medium RCF}) * (\text{Flute TakeUp})$$

For Double Wall start with:

$$A = (\text{Liner1 RCF}) + (\text{Liner2 RCF}) + (\text{Liner3 RCF}) + (\text{Medium1 RCF}) * (\text{Flute TakeUp1}) + (\text{Medium2 RCF}) * (\text{Flute TakeUp2})$$

Then if the combined weight of the outside liners is ≤ 85 lbs per 1000 square feet then
 $ECT = (A/6) * .8 + 12$ otherwise
 $ECT = (A/6) * 1.27 - 6$

Humidity Factors		Storage Time	
35%	1.1000	0 Days	1.0000
40%	1.0800	3 Days	0.7000
45%	1.0300	10 Days	0.6500
50%	1.0000	1 Month	0.6000
55%	0.9500	2 Months	0.5700
60%	0.9200	3 Months	0.5500
65%	0.8600	6 Months	0.5200
70%	0.8100	1 Year	0.5000
75%	0.7500		
80%	0.6700		
85%	0.6000		
90%	0.4800		
95%	0.2900		
100%	0.2500		

Pallet Spacing		UL Interlock	
Tight	1.0000	None	1.0000
Normal	0.9400	Some	0.8500
Wide	0.8500	All	0.7000

These settings are found under *Definitions/Environment Factors* in the TOPS CONFIG program.

Note: This method of ECT calculation is known as the "Over-Under 200" method.

Length to Width Ratio	Factor	Length	Width	Height
1.0	1.0500	0.9500	0.8500	0.8000
1.1	1.0500	1.0000	1.0500	1.1000
1.2	1.0500	1.0000	1.0000	1.0000
1.3	1.0000	1.0500	0.9500	0.9000
1.4	1.0000			
1.5	1.0000			
1.6	1.0000			
1.7	1.0000			
1.8	0.9500			
1.9	0.9500			
2.0	0.9500			
2.1	0.9500			
2.2	0.9500			
2.3	0.9500			
2.4	0.9500			
2.5	0.9500			
Over 2.5	0.8000			

Printing Factors	Flexo		Quick	
	Sample	1.1000	1.1000	1.1000
None	1.0500	1.0500	1.0500	1.0500
Simple	1.0000	0.9800	0.9800	0.9800
Average	0.9700	0.9500	0.9500	0.9500
Heavy	0.9300	0.9000	0.9000	0.9000
Complete	0.9000	0.8500	0.8500	0.8500

Flap Gap Factors	
Tight	1.0000
Up to 2 in	0.9700
2 in +	0.9500

These settings are found under *Definitions/Box Design Factors* in the TOPS CONFIG program.



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